



Transient Atmospheric Flows and Disturbances

Chapter 7

Impact of Storms on the Landscape

- **Storms influence our lives everyday**
 - **Storms impact the landscape**
 - **Negative effects**
 - Accelerate erosion,
 - Flood valleys,
 - Destroy buildings
 - Decimate crops
 - **Positive effects**
 - Promote diversity in vegetative cover
 - Increase the size of lakes and ponds
 - Stimulate plant growth with moisture
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Air Masses

- Characteristics

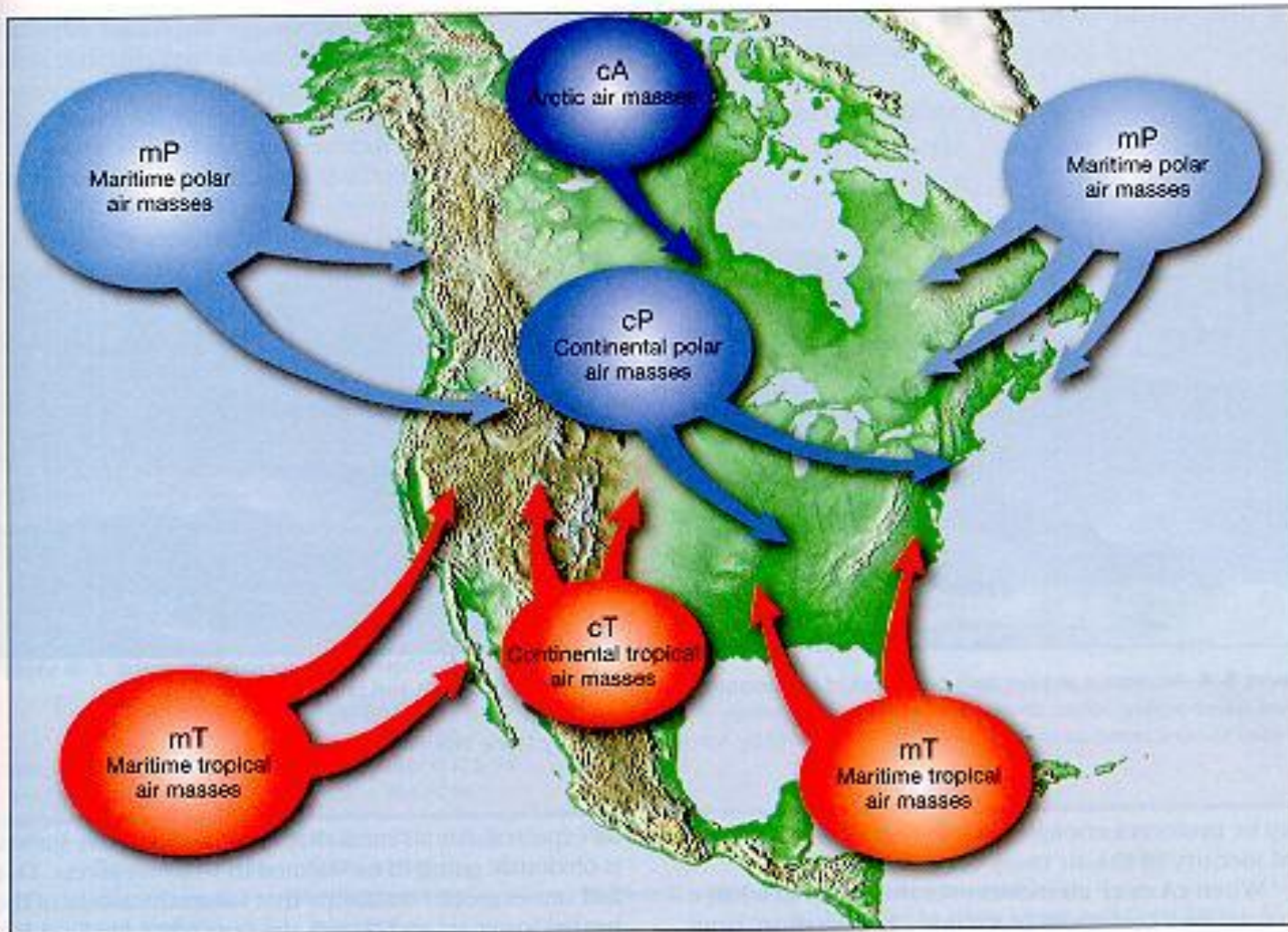
- Must be large
 - More than 1000 miles across and several miles deep
- Must have uniform properties in the horizontal dimension
- Must be a recognizable entity and travels as one

- Origin

- Develops its characteristics by remaining over a uniform land or sea surface long enough to acquire the temperature, humidity, and stability characteristics of the surface.
 - The air is usually stable stagnate air for a short time
 - Form in anti-cyclonic conditions called source regions
 - Ideal regions are ocean surfaces and extensive flat land areas that have a uniform covering of snow, forest, or desert.
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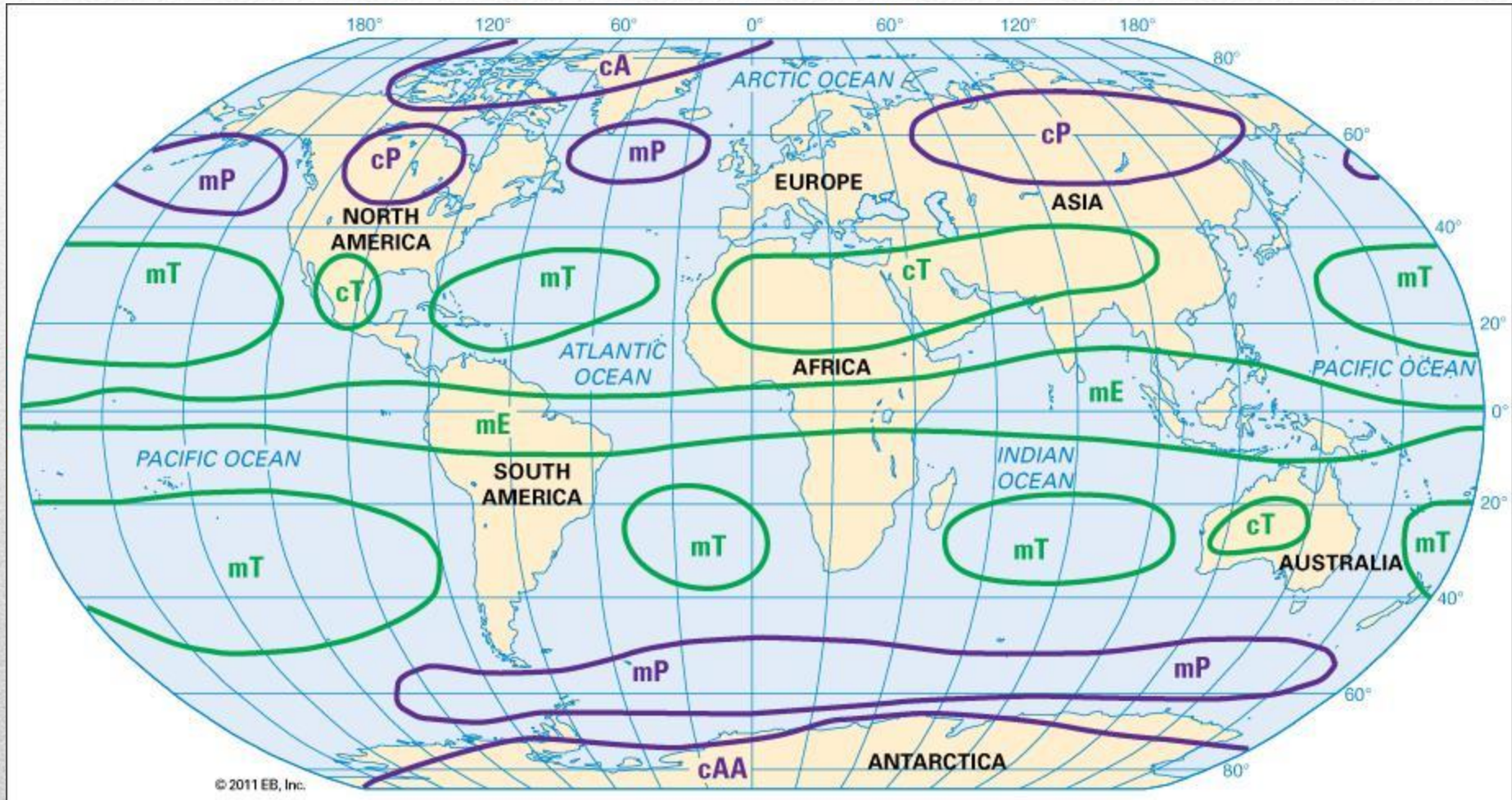
Air Masses

- **Classification of Air Masses**
 - Arctic/Antarctic A Antarctica, arctic Ocean and fringes, and Greenland
 - Very Cold, Very Dry, Very Stable
 - Continental Polar cP High-latitude plains of Eurasia and North America
 - Cold, dry, very stable
 - Maritime Polar mP Oceans in vicinity of 50 – 60 latitude
 - Cold, moist, relatively unstable
 - Continental tropical cT Low-latitude deserts
 - Hot, very dry, unstable
 - Maritime tropical mT Tropical and subtropical oceans
 - Warm, moist, or variable stability
 - Equatorial E Oceans near the equator
 - Warm, very moist, unstable
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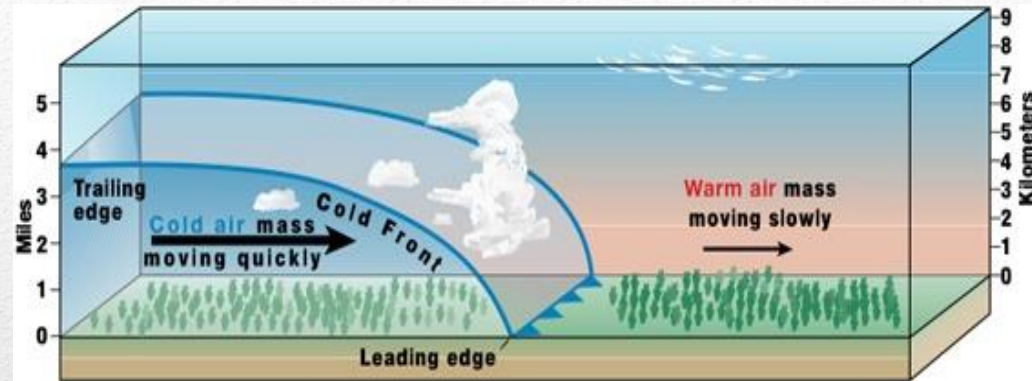
Air-mass source regions for North America. (Courtesy of Ward's Natural Science Establishment, Inc., Rochester, N.Y.)

World's Air Mass Source Regions

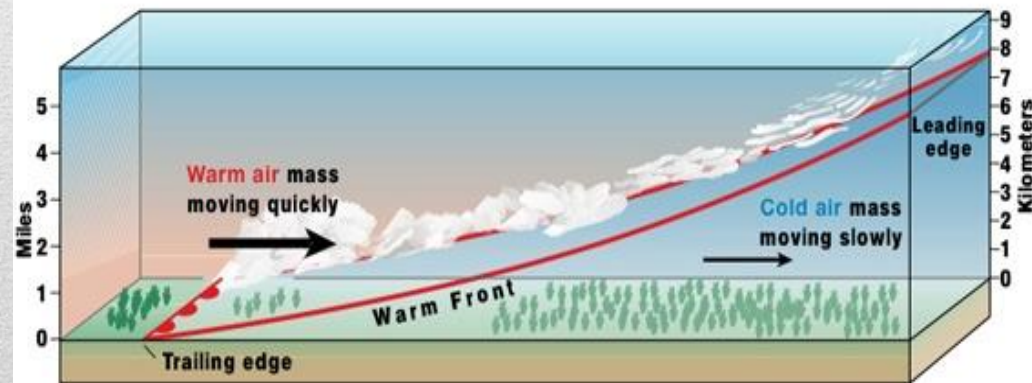


Fronts

- Boundary between a two unlike air masses
- Not two dimensional boundary at the surface, but a three dimensional zone of discontinuity
- Types of Fronts
 - Warm, Cold, Stationary, Occluded



(a)

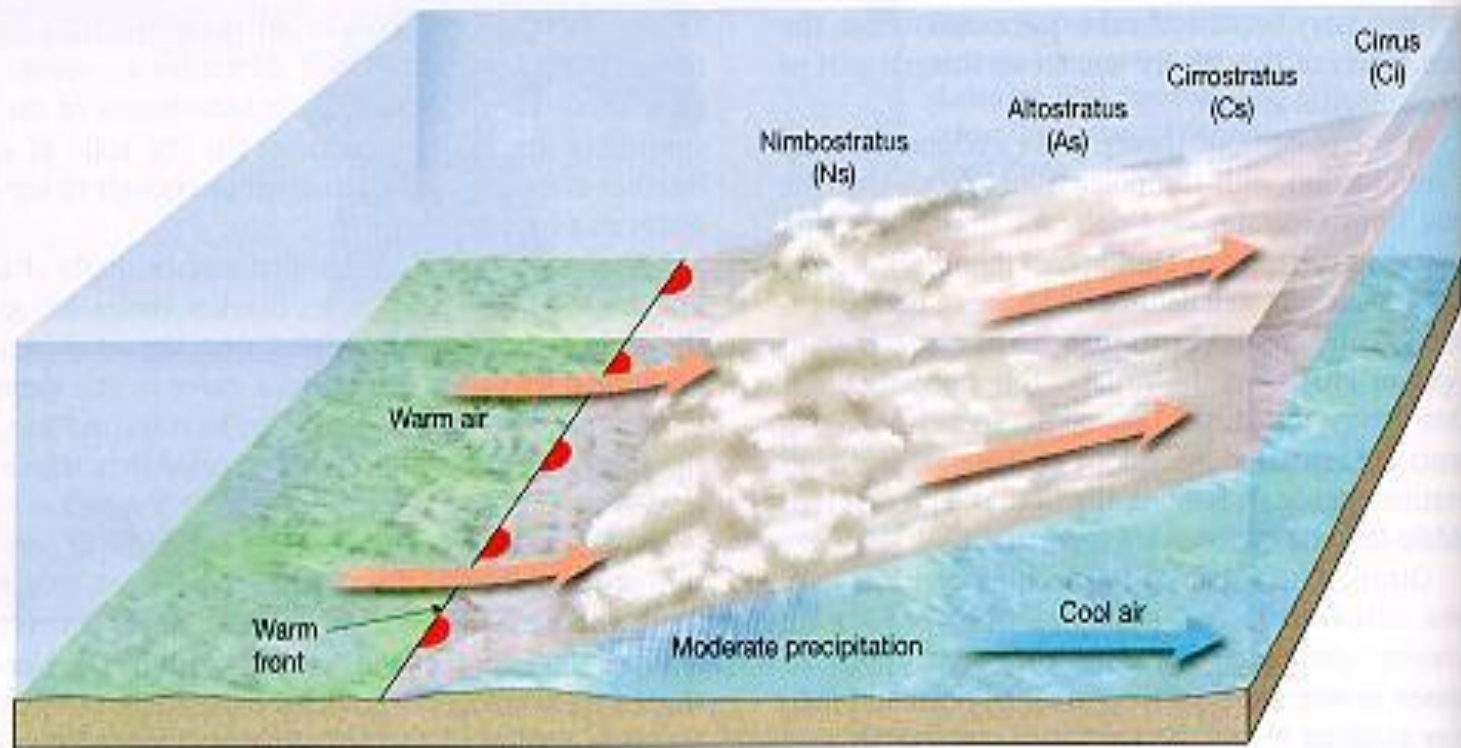


(b)

Warm Fronts

- Forms by advancing warm air
 - Slope is gentle, ascends over treating cool air, decreasing adiabatically as the air rises
 - Clouds form slowly and not much turbulence (high cirrus clouds), moving towards an altocumulus or altostratus
 - Broad precipitation, protracted and gentle
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Warm Fronts

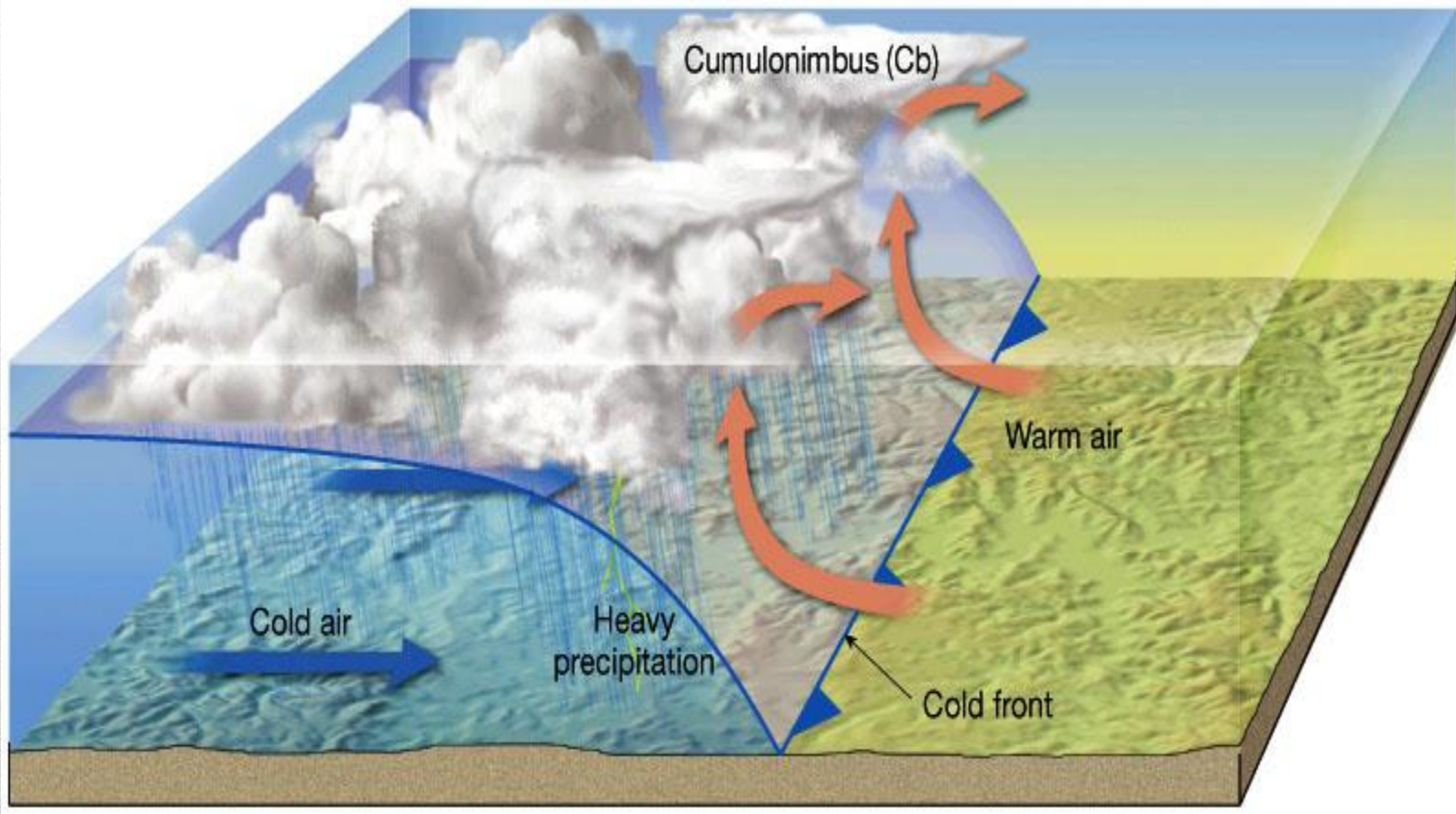


Warm front produced as warm air glides up over a cold air mass.

Cold Fronts

- Forms by advancing cold air
 - Is a steeper front than a warm front with a “protruding nose”
 - Moves faster than a warm front
 - Rapid lifting, unstable air, blustering and violent weather
 - Vertically developing clouds
 - If unstable air, precipitation can be showery or violent
 - Precipitation along the leading edge and immediately behind the ground-level position of the front
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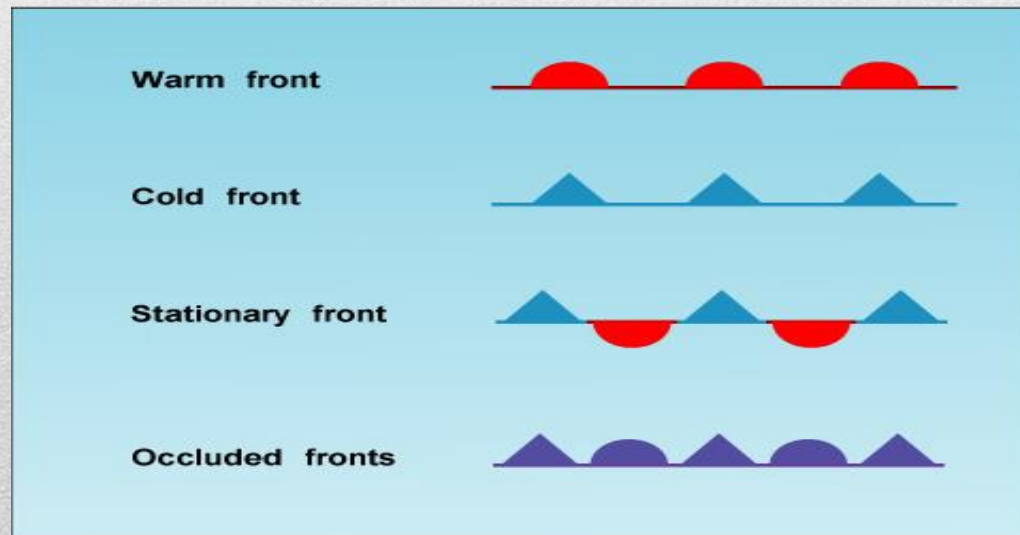
Cold Fronts

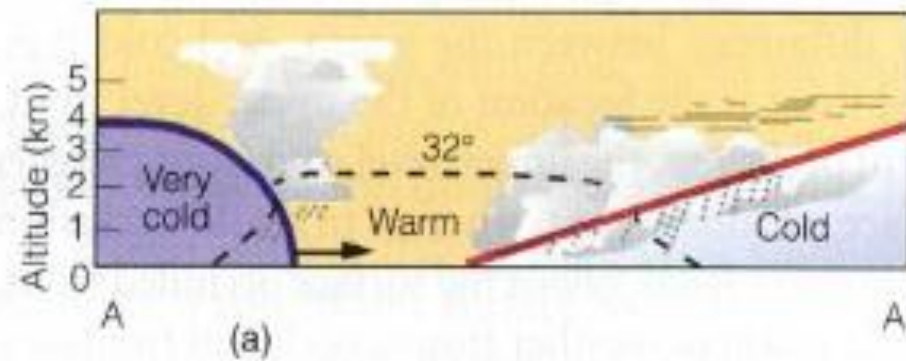
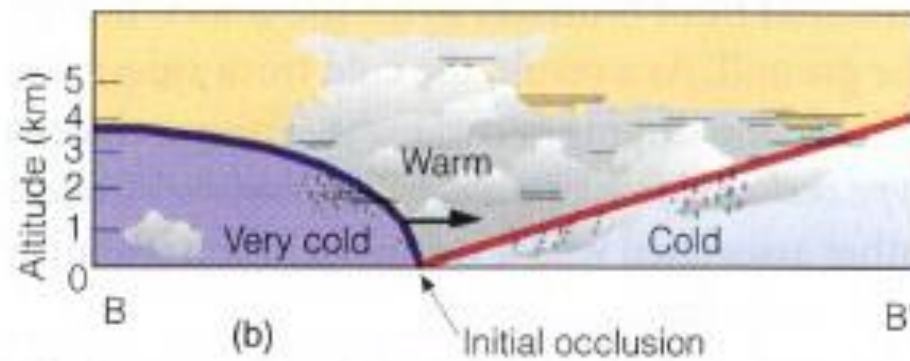
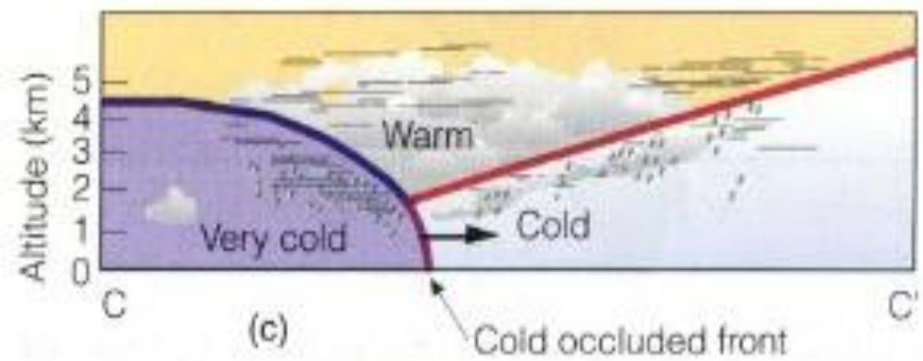


Stationary and Occluded Fronts

- Stationary front – gently rising warm air, limited precipitation
- Occluded front – when a cold front overrides a warm front.

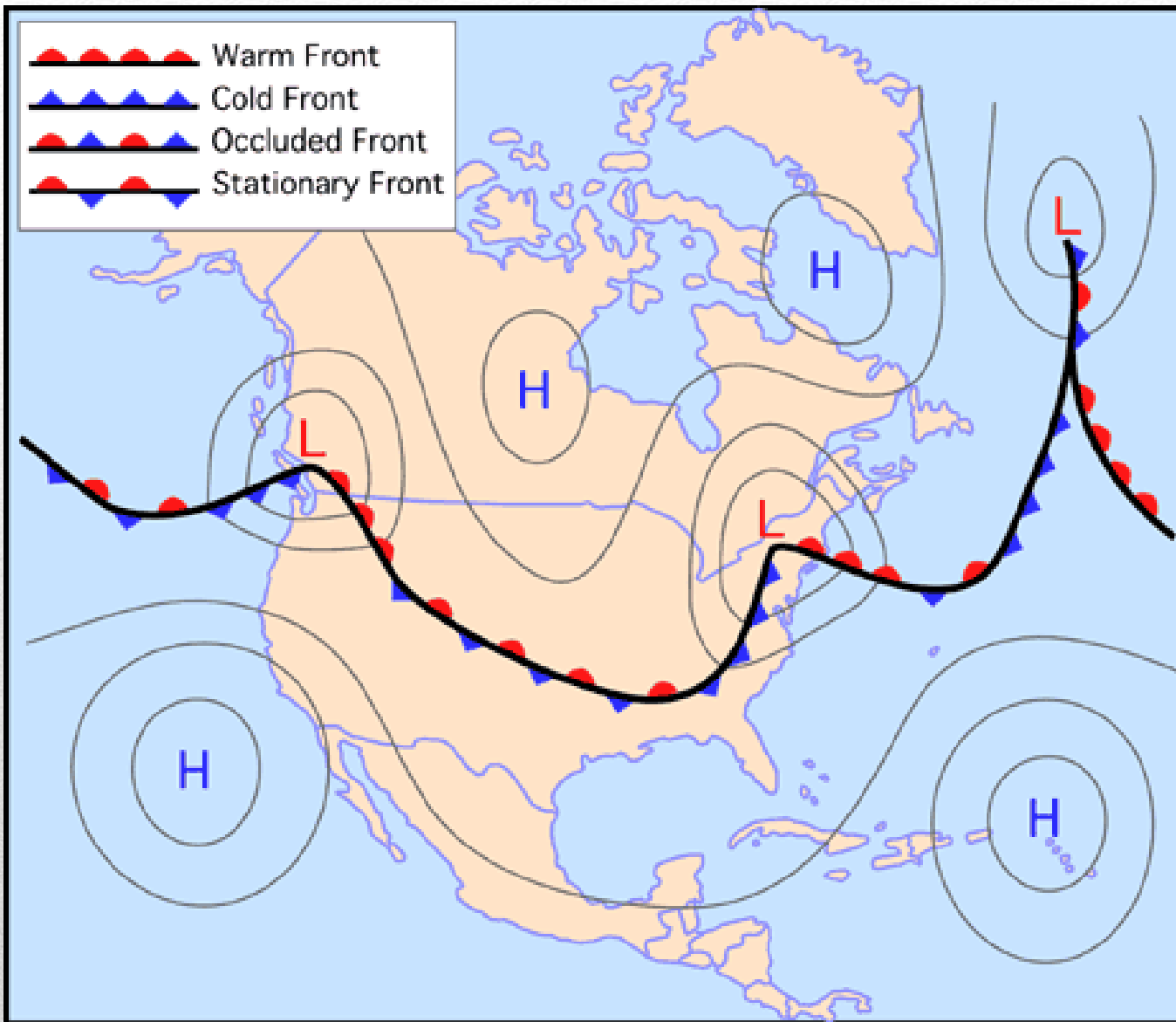
Front Symbols





Atmospheric Disturbances

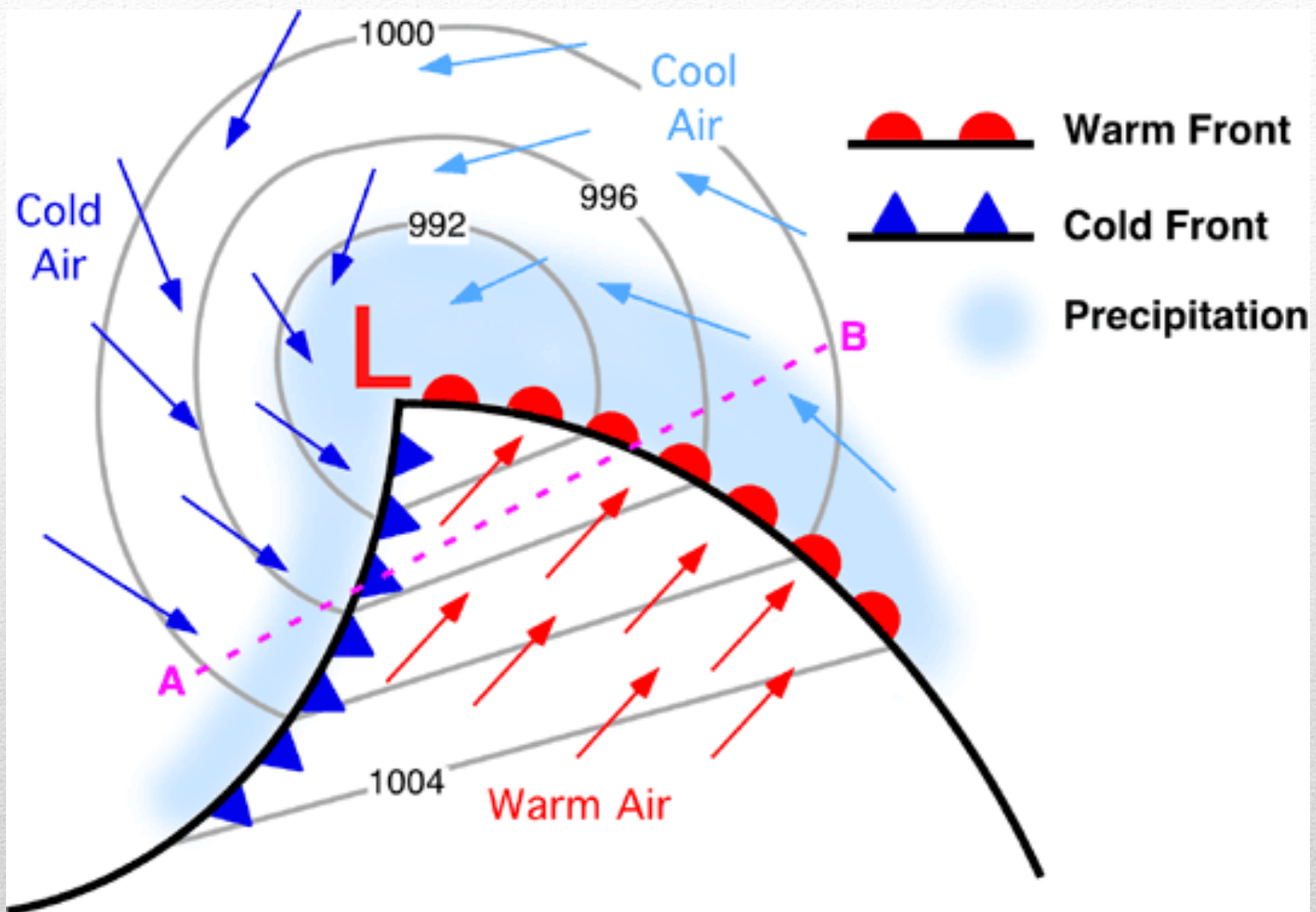
- Mid latitude Disturbances – mid-latitude cyclones and anticyclones on westerly waves
 - Tropical Disturbances – monotonous, same daily, monthly, yearly
 - Tropical cyclones (hurricanes, cyclones, or typhoons) on easterly waves
 - Localized Sever Weather
 - Thunderstorms and tornadoes
-



Mid Latitude Cyclones

- Characteristics

- Diameter – 1000 miles or more
 - Ground level center pressure 990 – 1000 Millibars
 - Clear-cut pressure trough extends southwesterly from the center
 - Counter-clockwise circulation pattern in the Northern Hemisphere – clockwise circulation pattern in Southern Hemisphere
 - Two fronts -- warm and cold, with a cool sector north and west of the center and warm sector to the south and east
 - Clouds – cumuliform clouds yield shower precipitation, originates in the warm air rising about the fronts and falls down through the front to reach the ground in the cool sector
-



Mid Latitude Cyclones

- Passing of the Front
 - Temperature decreases sharply
 - Winds shift from southerly ahead of the front to the northwesterly flowing it
 - The front is in a pressure trough, so pressure falls as the front approaches and rises after it passes
 - Clear skies are replaced by cloudiness and precipitation of the front
 - Similar changes but to a lesser magnitude occur when the warm front passes
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Mid Latitude Cyclones

- Movements
 - Generally moves west to east
 - Taking about 3 to 4 days to cross the U. S.
 - System has a cyclonic wind circulation with converging counterclockwise from all sides
 - The Cold front normally advances faster than the storms moves swinging it counterclockwise around the pivot center increasingly moving and displacing the warm sector
 - The Warm front usually advances more slowly than the storm
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Sky
clearing

Showers

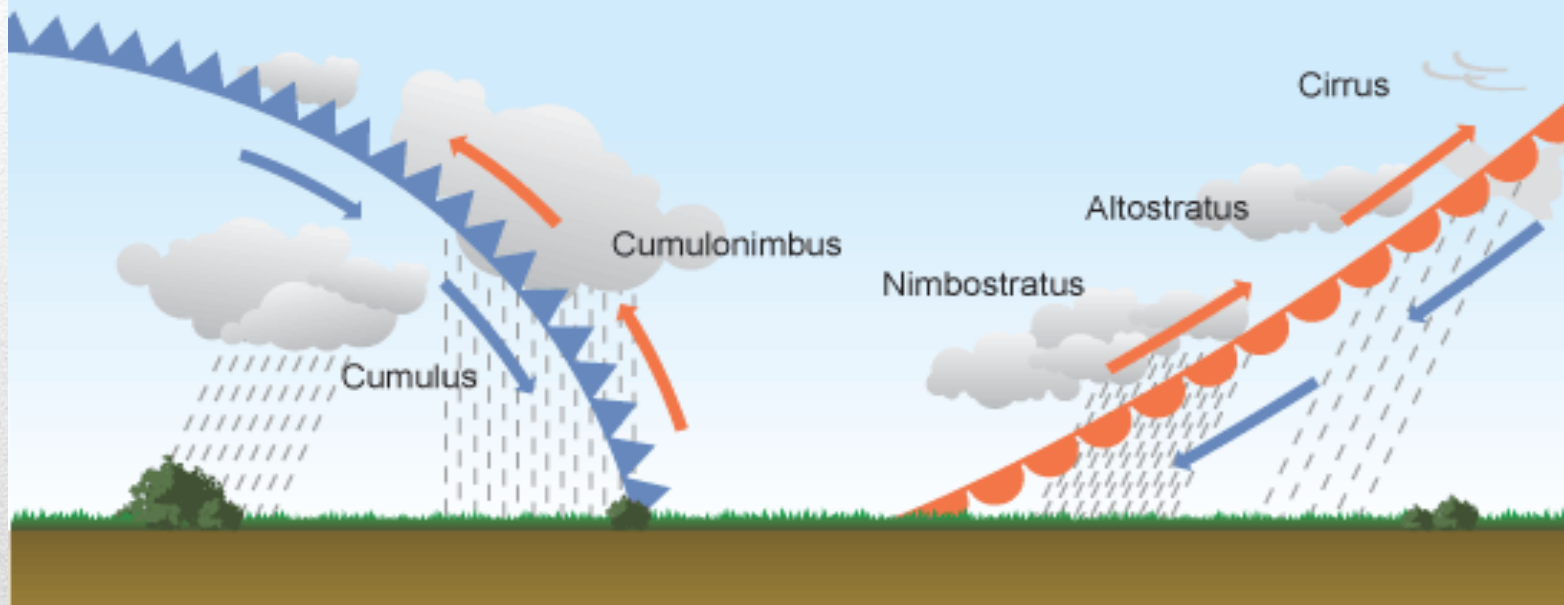
Heavy rain/
thunderstorms

Clear
and dry

Steady
rain

Drizzle

Sky
clearing,
high cloud



West

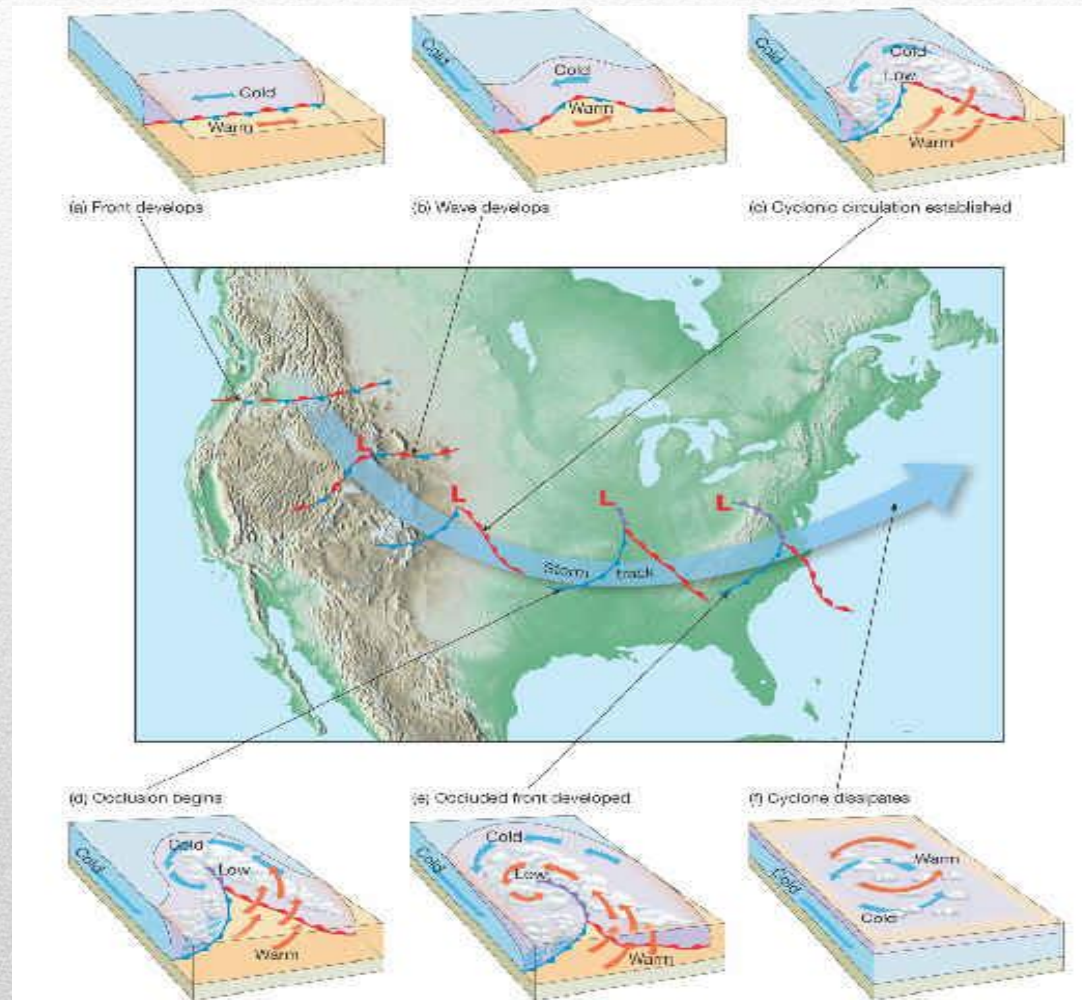
East

- Warm air rising
- Cool air sinking
- Warm front
- Cold front

Life of Mid Latitude Cyclones

- **Cyclogenesis**
 - Develop in 3 to 6 days to maturity, and about the same length to dissipate
 - Start as “**waves**” or **wave cyclone** along the polar front
 - **Occurrence and Distribution**
 - At any given time there are from **6 to 15 mid latitude cyclones** exist in the Northern Hemisphere
 - Occur at scattered but irregular intervals through the zone of the Westerlies
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Life Cycle of the Mid Latitude Cyclones

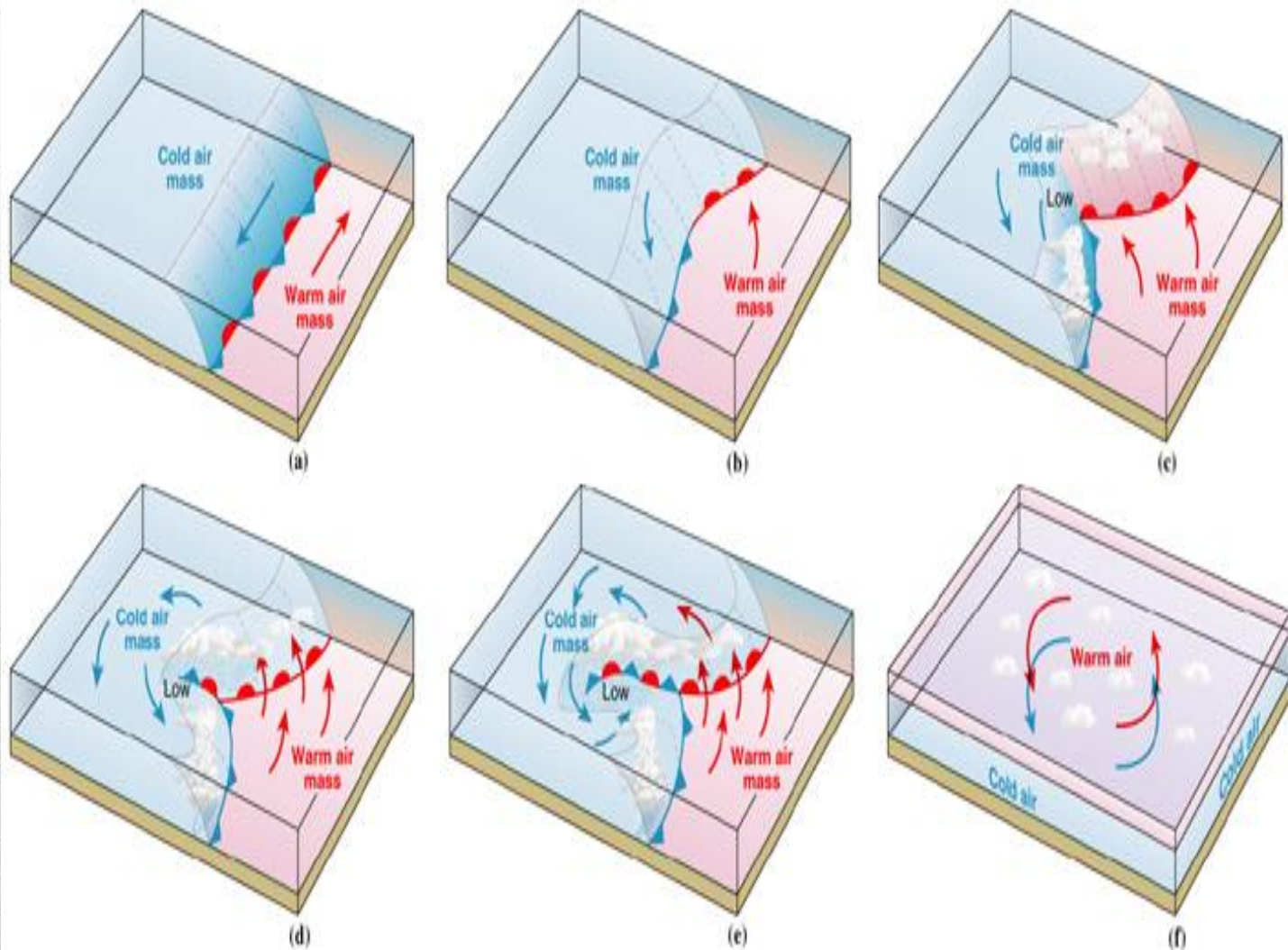


Life Cycle of the Mid Latitude Cyclones

- Front develops
- Wave appears along the front
- Cyclonic circulation is well developed
- Occlusion begins
- Occluded front is fully developed
- Cyclone dissipates

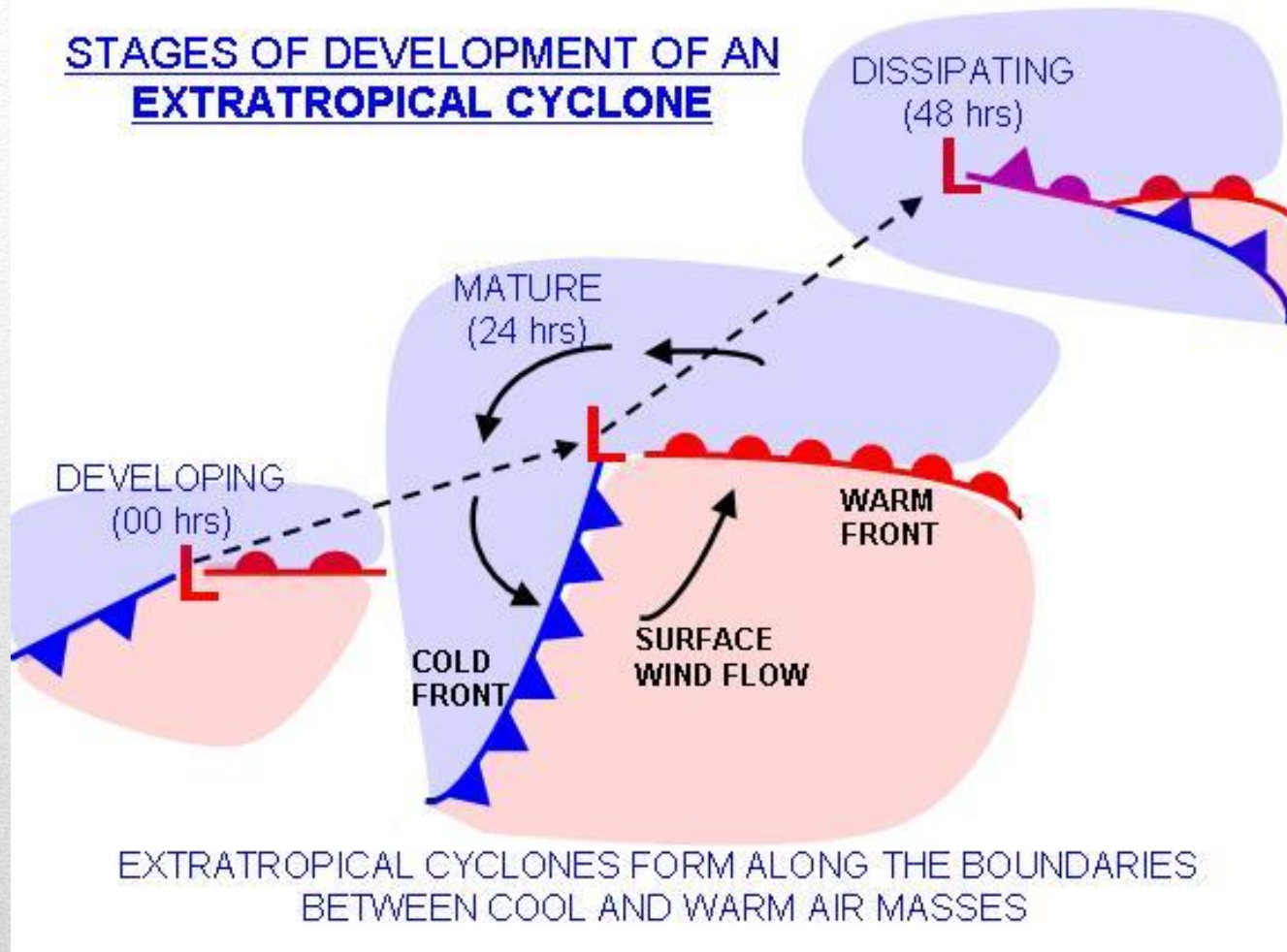
Remember this

Life Cycles of the Mid Latitude Cyclones



Remember this

STAGES OF DEVELOPMENT OF AN EXTRATROPICAL CYCLONE

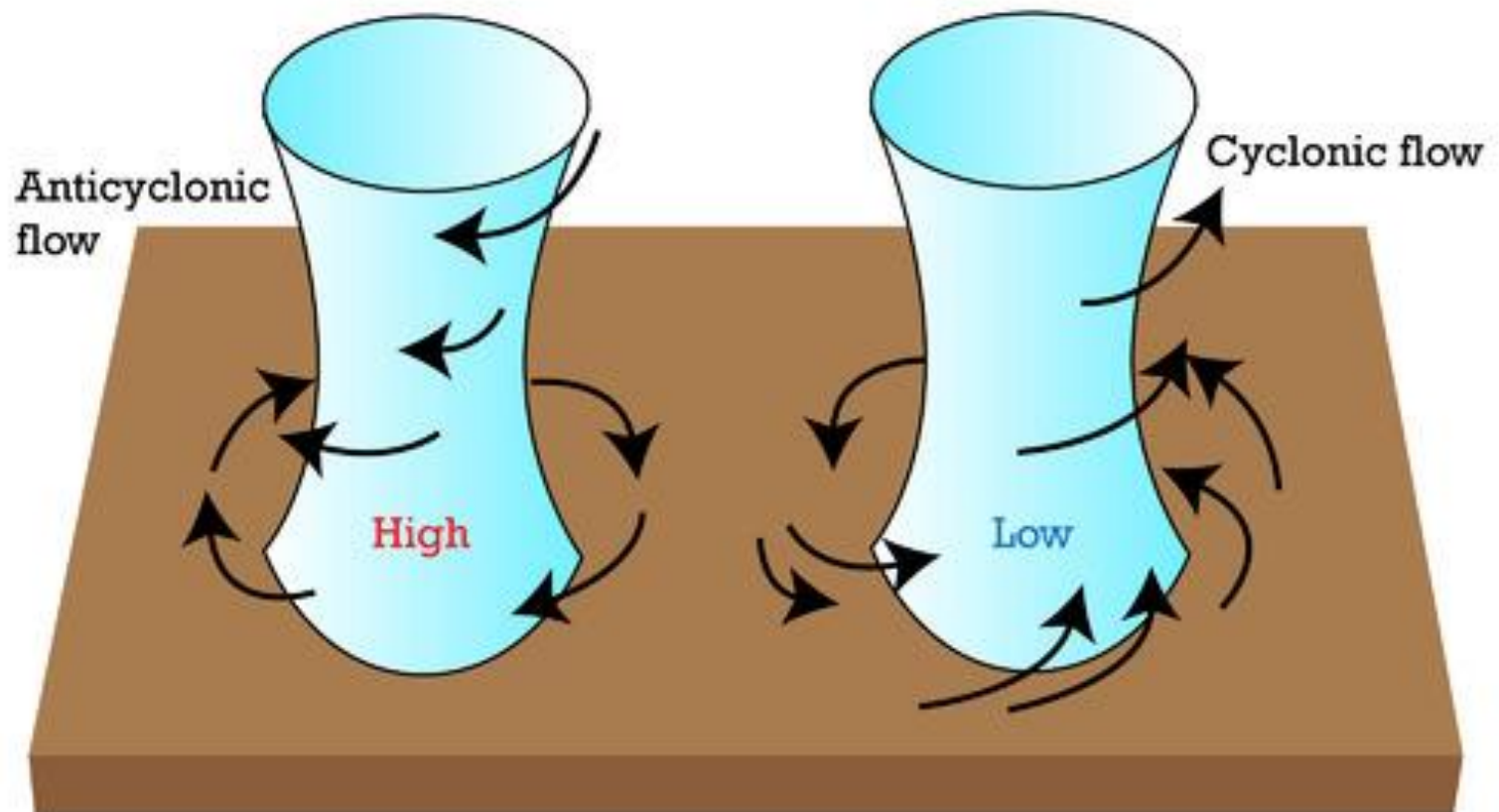


Another version of the life cycle
of a mid latitude cyclone

Mid Latitude Anticyclones – High Pressures

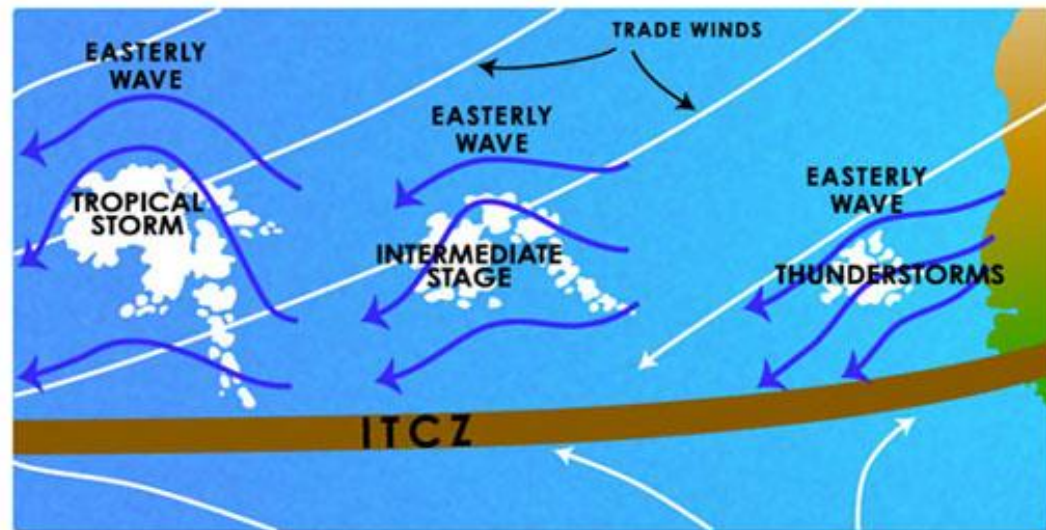
- Characteristics
 - High pressure – has air converging into it from above, subsiding, and diverging at the surface, clockwise rotation.
 - No air-mass conflict or surface convergence is involved
 - No fronts involved
 - Weather clear and dry with little or no opportunity for cloud formation
 - Wind movement very limited near the center, increases progressively outward
 - Very low temperatures in the winter
 - Prone to stagnate and remain over the same region for several days
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Cyclone and Anticyclone



Minor Tropical Disturbances: Easterly Waves

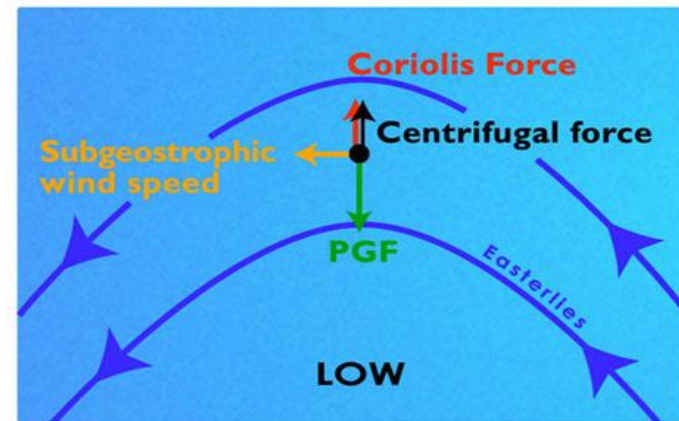
- Long but weak migratory low-pressure system
 - Occurs between 5 to 30 degrees of latitude
 - Tropical disturbances
 - Hurricanes, typhoons, Baguio, or cyclones
 - Develop from incipient low-pressures perturbations in trade-wind flow, called tropical disturbances.
 - Tropical depression – wind speed of less than 38 mph but has closed wind circulation pattern
 - Tropical Storm– winds between 39 to 73 mph
 - Hurricanes – winds greater than 74 mph
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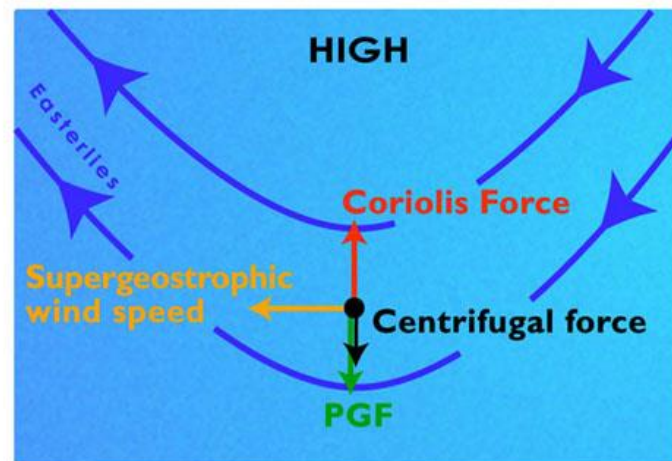
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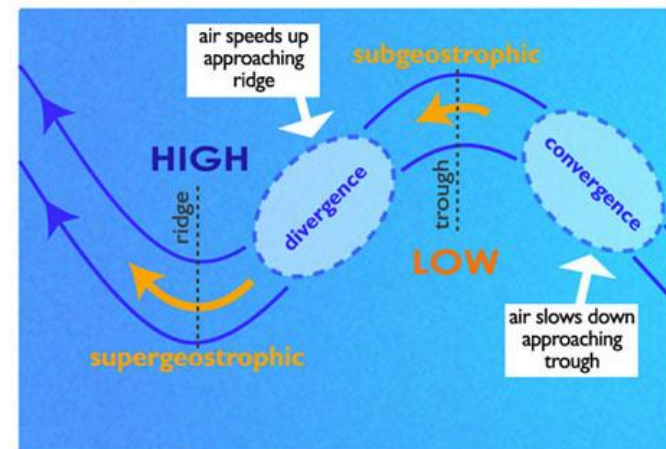
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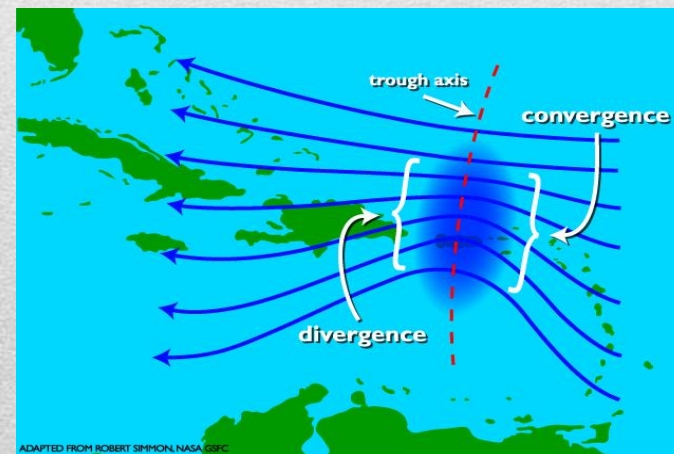
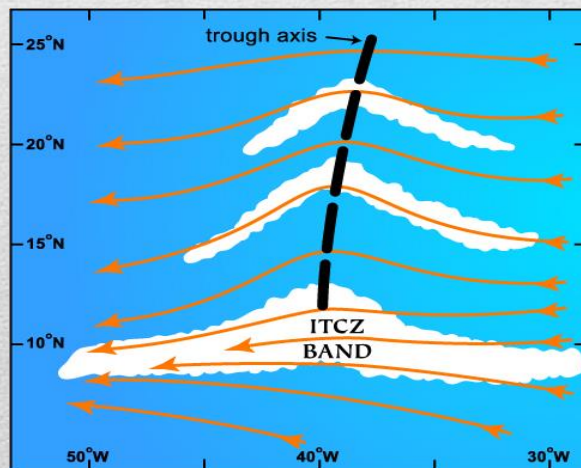
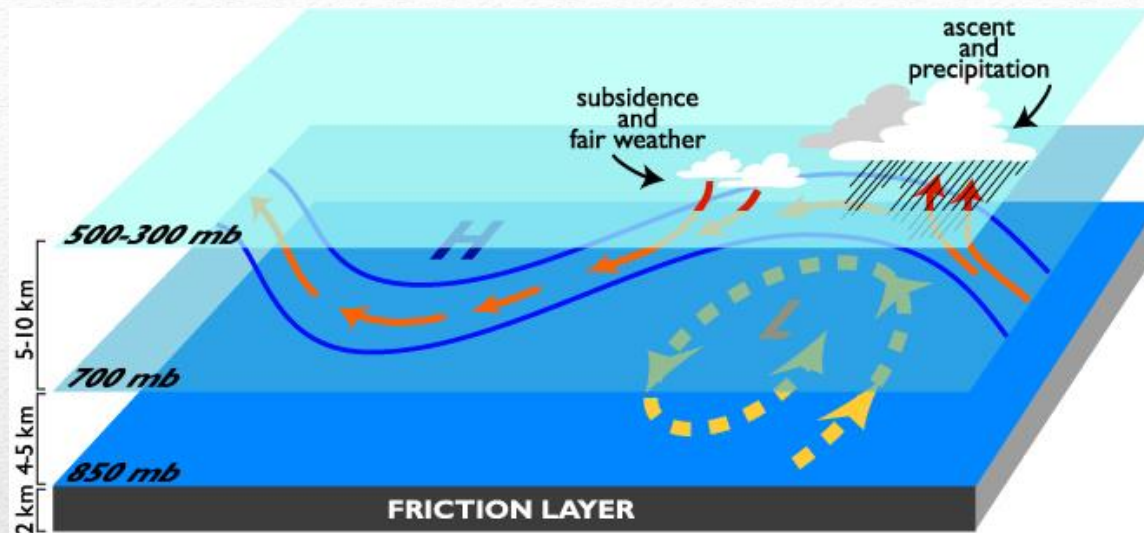


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ADAPTED FROM ROBERT SIMMON, NASA GSFC

Hurricanes

- Characteristics
 - Prominent low-pressure centers that are essentially circular with steep pressure gradient outward from the center
 - Converging cyclonic wind pattern “fuel” that powers the storm
 - Warm, water vapor-laden air spirals hurricanes into a storm
 - Intense updrafts within towering cumulonimbus clouds
 - Eye of the Hurricane, walls of rain bands
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anatomy of a hurricane

in the northern hemisphere

Outflow cirrus shield

Outflow

Warm rising air

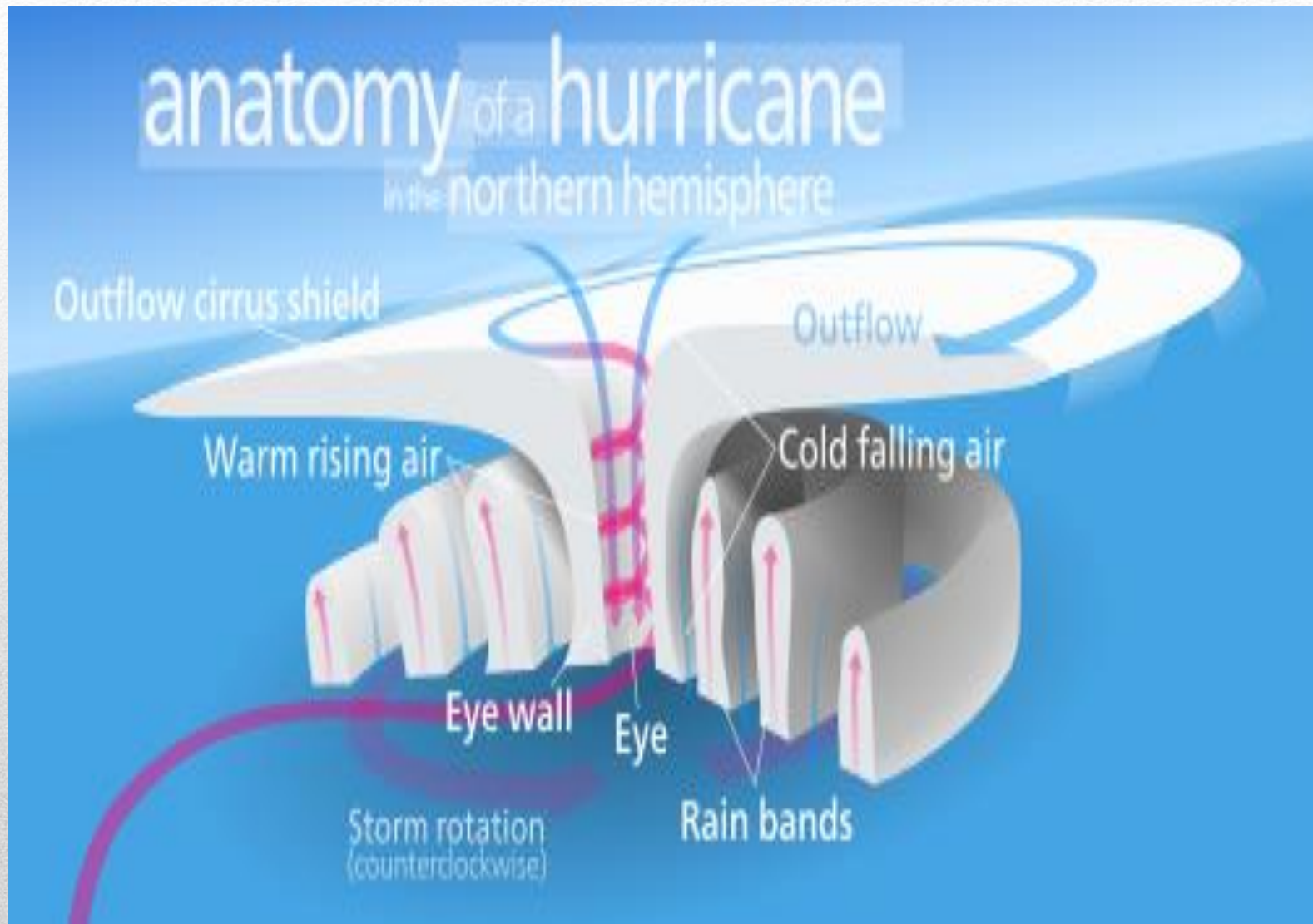
Cold falling air

Eye wall

Eye

Rain bands

Storm rotation
(counterclockwise)



Hurricanes

- Origin

- Form only over warm oceans in the tropics at least a few degrees north or south of the equator
- Mechanism of formation not fully understood
- Always develop out of a preexisting disturbance in the tropical troposphere.
- Easterly waves provide low-level convergence and lifting that catalyze the develop
- Less than 10% of all easterly waves grow into hurricane

- Movement

- Stay within the trade-winds moving east to west.

- Damage and Destruction

- Saffir-Simpson Hurricane Scale 1-5 in intensity
- Storm Surge -- Ocean bulge – wind driven water that pounds into a shoreline

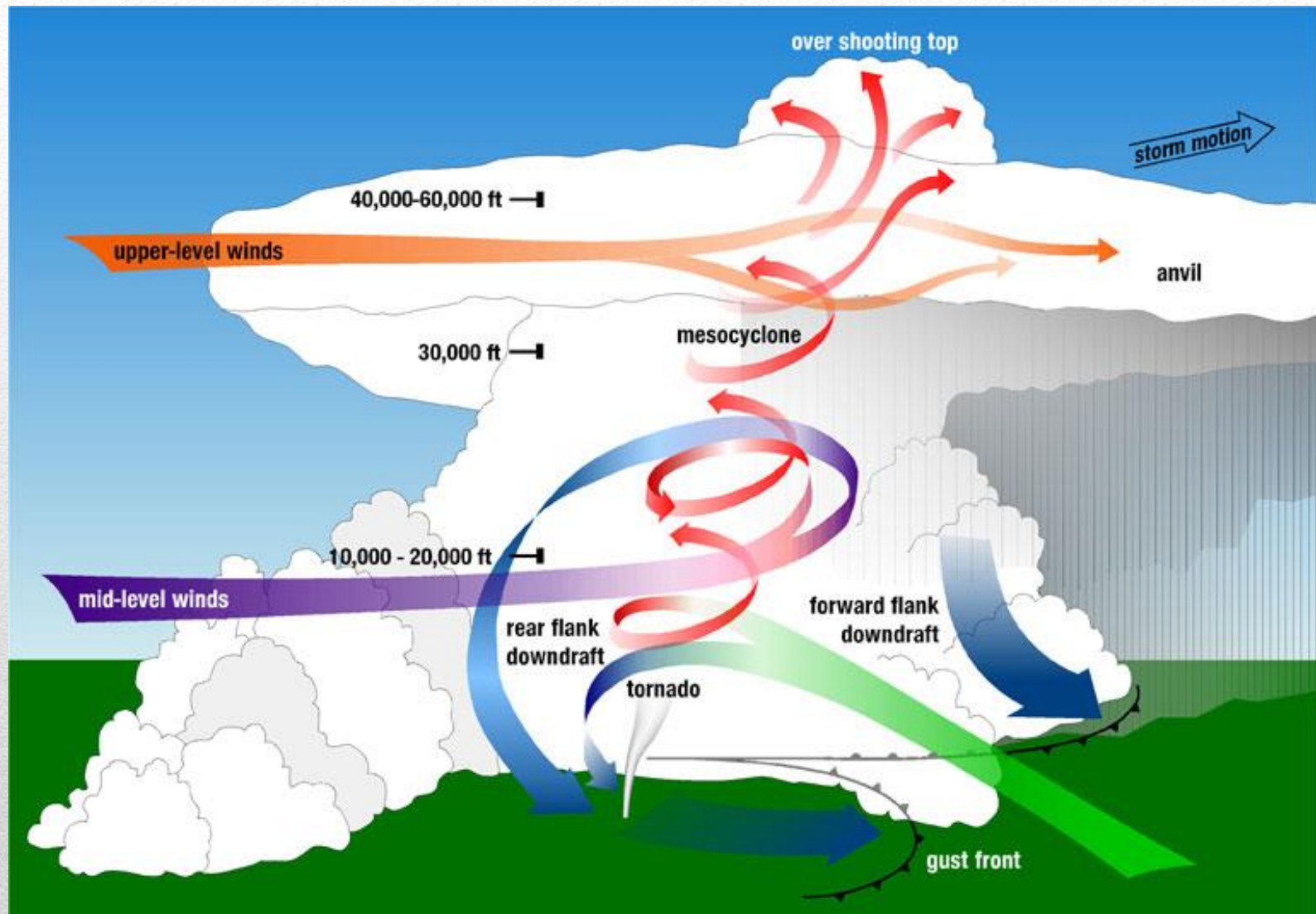


Hurricanes



Localized Severe Weather

- Thunderstorms
 - Defined as a violent convective storm accompanied by thunder and lightning
 - Found frequently found in conjunction with other kinds of storms
 - Triggered by unstable uplift
 - Formation called the cumulus stage
 - Mature stage – in which updrafts and downdrafts coexist as the cloud continues to enlarge – heavy rain accompanied with hail, blustery winds, lightning, and the growth of the anvil top
 - Dissipating stage -- with light rain ending the turbulence.
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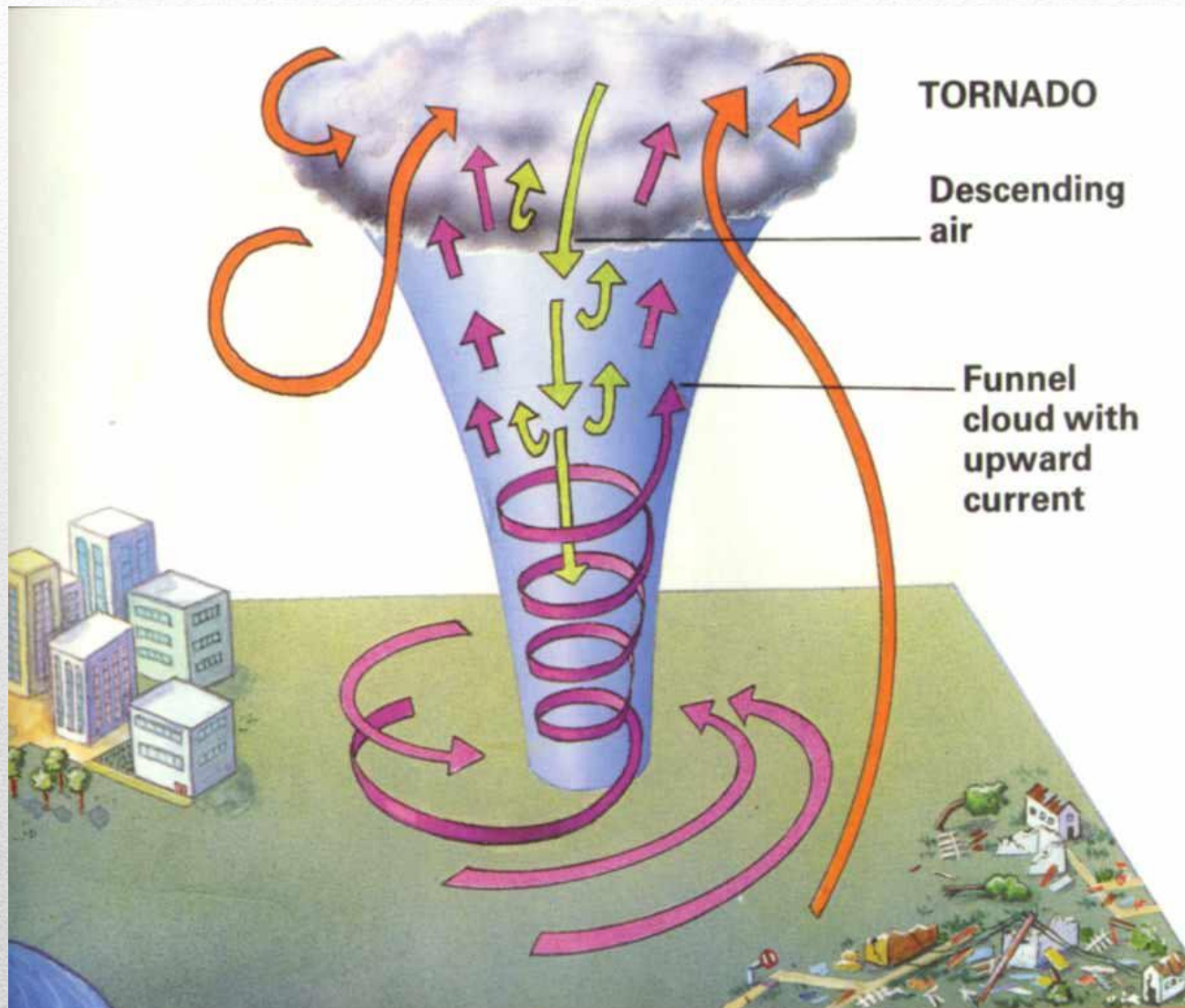
Tornadoes

- Characteristics

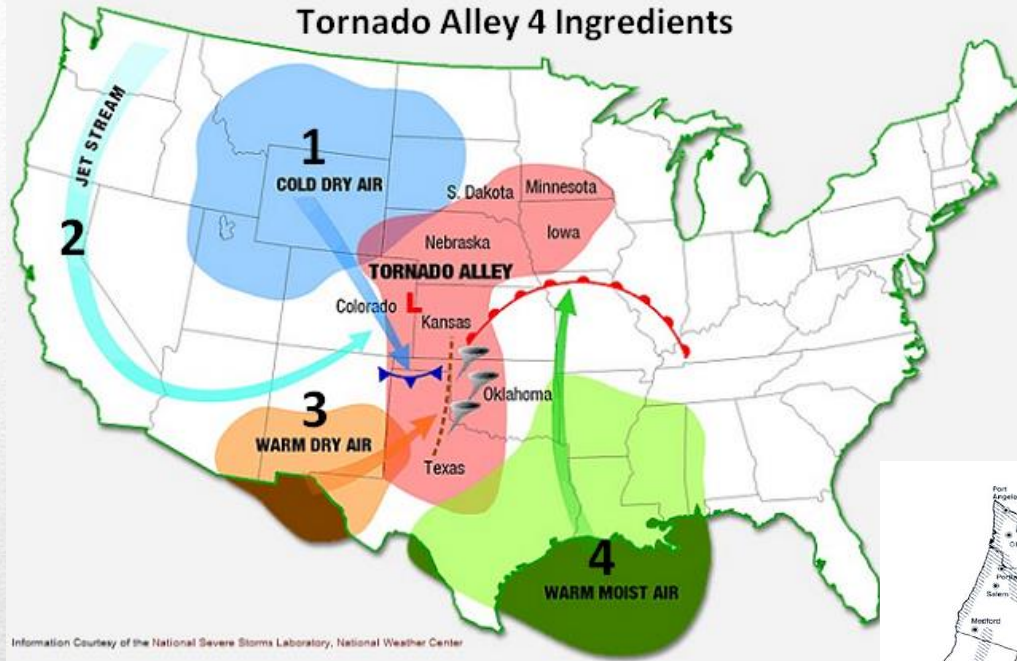
- Very small and localized
 - Most destructive of all atmospheric disturbances
 - Most intense vortex in nature , deep low pressure cell surrounded by a violently whirling cylinder of wind
 - Less than a quarter of a mile in diameter but most extreme pressure gradients known (100-millibar difference from the center to the edge)
 - Upswept water vapor condenses into a funnel cloud
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Tornadoes

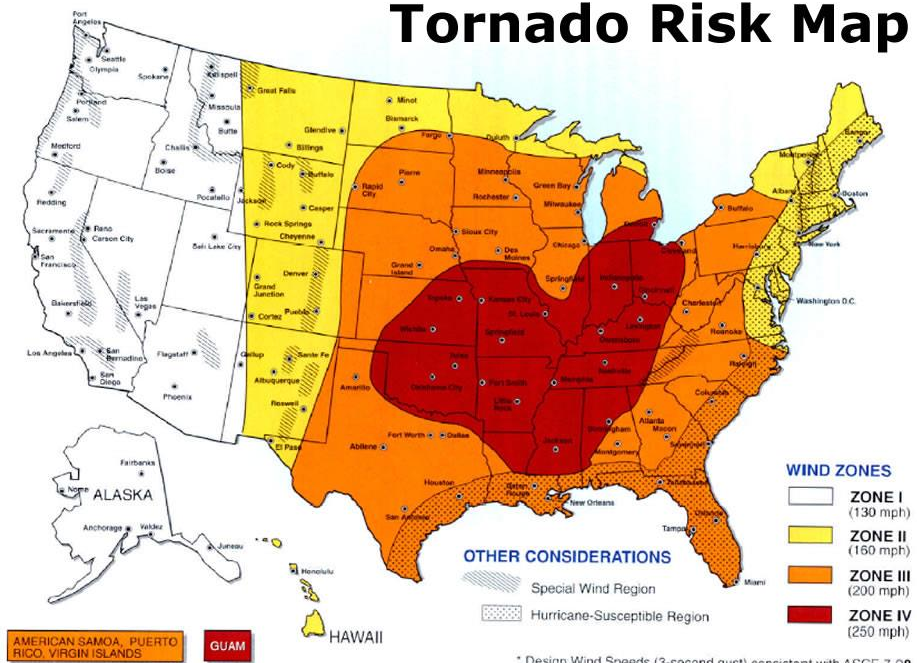
- Characteristics
 - Advances along an irregular track that generally extends from southwest to northeast in the US
 - Fujita tornado intensity scale for intensity
 - Formation – develop in the warm moist unstable air associated with a mid latitude cyclone, along the squall line
 - Develops out of mesocyclone, but only about half of all mesocyclones formed result in a tornado
 - More than 90 % of tornadoes happen in the US in Tornado Alley
-



Tornado Alley 4 Ingredients



Tornado Risk Map



Tornadoes

